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Effect of Some Treatments on Reducing Sunburn in Wonderful Pomegranate Fruit Trees

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THIS study was carried out during two successive seasons of 2011 and 2012 in order to study the effect of spraying purshade at (2, 4 %), $Ca(OH)_2$ at (1, 2 %) and Kaolin at (2, 4 %) on reducing fruit sunburn of three years old Wonderful pomegranate (*Punica granatum* L.) trees grown in sandy soil of private farm at Alexandria desert road, Egypt. All experimental trees were sprayed twice (21 days after fruit set and one month later) in each season. Results showed that, Kaolin at 2 % significantly increased fruit weight (g), yield (Kg/tree) and non-edible part (%) as compared with the control and the other treatments. Meanwhile, Kaolin application at 4 % led to a marked reduction in cracked and sunburned fruits, increasing the marketable fruits. Also, treatment with Kaolin at 4 % increased fruit chemical contents (TSS, TSS/acidity, vitamin C, anthocyanin pigment and total sugars) and redness fruit as compared to the other treatments. While, Ca $(OH)_2$ at 2 % caused a significant increase in fruit length and diameter (cm). In addition, Purshade at 4 % caused the highest increase in fruit edible part (%) and acidity (%).Generally, all treatments were effective in reducing the percentage of Wonderful pomegranate fruit sunburn. In addition, the treatment of Kaolin at 4 % was more effective than the other treatments under the experimental conditions.

Keywords: Pomegranate, Purshade, $Ca(OH)_2$, Kaolin, Fruit quality.

Pomegranate (*Punica granatum L.*) is one of the oldest known edible fruits and is capable of growing under different agro-climatic conditions ranging from the tropical to sub-tropical (Levin, 2006 and Jalikop, 2007). The pomegranate is native to the subtropics and mild temperate regions. Pomegranates grow best in areas that have long, hot, somewhat dry summers and cool winters. Pomegranates are especially sensitive to sun because they are terminal-bearing plants, with thin branches that bend with the increase in fruit weight as the season progresses (Melgarejo *et al.,* 2004). Pomegranates are picked in late summer to early autumn, therefore exposing the fruit to high temperatures throughout the summer resulted in the incidence of sunburn damages which cause grower losses that may exceed 30% of the harvested fruit (Melgarejo and Mart´ınez, 1992).The pomegranate fruit sunburn damage is clearer in arid and semi-arid regions where the tree canopy and fruits are exposing to excessive heating. In this respect, many investigators clarified that sunburn in horticultural crops is considered one of the major problems in areas with intense light and high temperature (Wünsche *et al.,* 2001, Schrader *et al.,* 2003 and Weerakkody *et al.,* 2010).

In Egypt, the total cultivated area of pomegranate is 34450 feddan with total fruit production of 106260 tons, according to the latest statistics of the Ministry of Agriculture and Land Reclamation (2013). The temperature in summer may also increase above 40°C, causing sunburn damage to the fruits, leading to loss in the quality and consequently the fruit prices. Moreover, sunburn in fruits can be caused by the excess of both heat and radiation (mainly UV-B) (Glenn *et al.*, 2002). Therefore, spraying anti- sunburn compounds containing calcium carbonate on pomegranate fruit trees that growing under hot-dry climates is effectively counteracted the adverse effects of high temperature and UV radiation on both yield and fruit quality (Curry *et al.,* 2004 and Morsy *et al.,* 2008). Compounds containing calcium carbonate such as Purshade as well as those containing kaolin as protective film that acts as a superior reflective particle barrier to the harmful effects of solar radiation and water stress (Nakasone & Paul, 1998 and Chadha & Shikhamany, 1999). Surround treatments have been successfully applied in different fruit species and crops to improve the physiological response to weather conditions, like heat stress and sunburn (Jifon & Syvertsen, 2003, Gindaba & Wand, 2007 and Glenn, 2009).

The present investigation aimed to study the effect of some white coating (Purshade, $Ca(OH)_2$ and Kaolin) on reducing sunburn in Wonderful pomegranate fruit.

Materials and Methods

Three years old orchard of Wonderful pomegranate grown at farm located on Alexandria desert road, Egypt, was used for this investigation during the 2011-2012 growth seasons. The trees were planted at 5x5 m apart in sandy soil under drip irrigation system and received the same horticultural managements. Twenty one trees in similar age and vigor were selected and divided into seven different treatments including the control, as follows:

- Control
- Purshade at 2%
- Purshade at 4%
- $Ca(OH)_2$ at 1%
- $Ca(OH)_2$ at 2%
- Kaolin at 2%
- Kaolin at 4%

The experiment was designed as a completely randomized block design with three replicates/treatment and one tree per each. The trees canopy surface of all experimental trees was sprayed twice at 21 days after fruit set and one month later in each study season.

Field observations and laboratory measurements were achieved and conducted out over the periods of this research as follows:

Yield and fruit physical characteristics

Fruits of selected Wonderful pomegranate trees were harvested on 1st of October in each studied season and weighted. Then, total yield /tree was recorded as Kg/ tree and the total fruit number/tree was recorded. The number of cracked & sunburned fruits/tree was counted and their percentages were calculated. Marketable fruits/tree (%) was calculated.

Fruit physical properties

A sample of 10 fruits of each replicate (tree) was randomly selected for determining the following physical properties:

Fruit length & diameter (cm) were determined. Selected fruits were hand peeled in the laboratory, then, separately, their rind and capillary membranes (non-edible part) and weighted, thus calculating the aril (edible part) weight/fruit by the difference between total fruit and non-edible part weights.

Fruit firmness was determined using Shatilon's instrument for measuring firmness of pomegranate (g/cm^2).Colour was determined using a Minolta CR-300 colorimeter. Lightness, fruit skin colour was measured on the most colored part of fruit using a colorimeter (CR-400, Minolta, Japan), which provided CIE L*, a*, and b* value. L* represents the relative lightness of color with a range from 0 to 100, being small for dark color and large for light color. Both a* and b* scales extend from 60 to 60. Negative a* value indicates greenness and positive for redness, while b* is negative for blueness and positive for yellowness (McGuire, 1992).

Fruit juice chemical composition

Fruit juice was extracted and the total soluble solids were determined by hand refractometer.

Ascorbic acid (mg V.C./100ml juice), total sugars(%)were determined calorimetrically in sample of 5 ml juice, according to the method described by Dubois *et al.* (1956).

The amount of the estimated sugars in each sample was calculated in term of glucose and total acidity percentage was determined by titrating 5 ml juice against 0.1 NaOH using phenolphthalene as an indicator.

Values of total acidity were expressed in grams of citric acid per 100 ml juice as described in (A.O.A.C., 1985), then, T.S.S/acid ratio was calculated. Total anthocyanin content (%) in fruit juice as described by Hsia *et al.* (1965).

Statistical analysis

The collected data were analyzed using Randomized Complete Blocks Design and subjected to statistical analysis as described by Sendecor and Cochran (1990). Means were differentiated using Duncan's Multiple Range Test (Duncan, 1955).

Results and Discussion

Yield and fruit physical characteristics

Results in Table 1 cleared an evident increase in fruit length (cm) was noticed on fruits sprayed with $Ca(OH)_2$ at 2% in the two seasons and in fruit diameter (cm) with second season. Moreover, treatment Kaolin at 2% caused the highest increase in fruit diameter (cm) as compared with all other treatments in first season.

TABLE 1. Effect of some treatments on Wonderful pomegranate fruit length and diameter (cm) during 2011 & 2012 seasons.

Treatments	Fruit length (cm)				Fruit diameter (cm)			
	2011		2012		2011		2012	
Control	7.92	b	7.90	c	8.00	c	8.25	d
Purshade 2%	8.05	b	7.89	c	8.01	c	8.71	bc
Purshade 4%	8.41	a	8.00	bc	8.39	b	8.41	cd
$Ca(OH)_2$ 1%	7.89	b	8.43	ab	8.30	b	9.25	a
$Ca(OH)_2$ 2%	8.51	a	8.60	a	8.35	b	9.21	a
Kaolin 2%	8.46	a	8.03	bc	8.55	a	9.00	b
Kaolin 4%	7.91	b	8.13	a-c	8.38	b	8.95	b

Values have the same letter are not significantly different at 5% using Duncan's Test.

Data in Table 2 cleared that, purshade at 4% recorded the highest fruit edible part in the first season. While, kaolin at 4% had the highest fruit edible part (%) in the second one. Moreover, in both seasons of study, kaolin at 2% significantly increased fruit non-edible part (%) as compared with all other sprayed treatments.

TABLE 2. Effect of some treatments on Wonderful pomegranate fruit edible part (%) and non-edible part (%) during 2011 & 2012 seasons.

Treatments	Fruit (edible part) (%)				Fruit (non-edible part) (%)			
	2011		2012		2011		2012	
Control	50.0	e	51.0	d	50.0	a	49.0	d
Purshade 2%	53.0	d	50.0	e	47.0	b	50.0	c
Purshade 4%	56.0	a	53.0	c	44.0	d	47.0	e
$Ca(OH)_2$ 1%	50.0	e	48.0	f	50.0	a	52.0	b
$Ca(OH)_2$ 2%	55.0	b	54.0	b	45.0	cd	46.0	f
Kaolin 2%	49.0	f	46.0	g	51.0	a	54.0	a
Kaolin 4%	54.0	c	56.0	a	46.0	bc	44.0	g

Values have the same letter are not significantly different at 5% level using Duncan's Test.

All treatments under study at all concentrations significantly increased fruit weight (g) and yield (kg) compared with control in both seasons (Table 3). The highest values (432.5 and 450 g) for fruit weight and (22.03 and 32.40 kg) for yield/tree was obtained with the2% of Kaolin treatment. The same results were announced by Attra (1999). The promoting effect of $CaCO_3$ and Purshade on yield and cluster weight was supported by the results of Kerns & Wright (2000), Glenn *et al*. (2001), Morsy *et al*. (2008) and Faissal *et al.* (2011). The reduction of foliage temperature by using anti- sunburn compounds may improve netphoto synthesis through reducing daytime stomatal closure and daytime respiration (Glenn *et al.*, 2001), especially in hot dry climates, leading to better yield. Also, Aly *et al.* (2010) found that, the film reflect seemed to be increased fruit weight as well as yield as compared with no-film reflect treatment.

TABLE 3. Effect of some treatments on Wonderful pomegranate fruit weight (g) and fruit yield/tree (kg) during 2011 & 2012 seasons.

Treatments	Fruit weight (g)				Fruit yield/tree (kg)			
	2011		2012		2011		2012	
Control	400.1	g	403.0	f	20.00	b	25.79	d
Purshade 2%	406.7	e	420.0	c	19.10	c	30.37	ab
Purshade 4%	418.3	b	430.0	b	18.37	c	27.65	cd
$Ca(OH)_2$ 1%	402.6	f	407.0	e	20.10	b	28.49	bc
$Ca(OH)_2$2%	415.5	c	418.0	c	18.67	c	28.01	cd
Kaolin 2%	432.5	a	450.0	a	22.03	a	32.40	a
Kaolin 4%	412.1	d	410.0	d	18.97	c	26.36	cd

Values have the same letter are not significantly different at 5% level using Duncan's Test.

Data in Table 4 clearly show that, cracked and sunburned fruits % was significantly affected by using white coating treatments (Purshade, $Ca(OH)_2$ or Kaolin) at different concentrations. Percentages of cracked fruits and sunburned fruits were significantly reduced with using all treatments comparing with un-treating fruits. The lowest significant percentage was found with kaolin at 4% treatments in both seasons of study. On the contrary, all the treatments at all concentrations significantly increased the marketable fruits (%) compared with control, (Table 4). The highest values (86.20 and 85.00 %) were obtained from Kaolin at 4%, while the control resulted in the lowest values (65.00 and 61.00 %) in the both seasons of the study, respectively.

These results are in harmony with those obtained by Schrader *et al.* (2003), where sunburn on fruit surfaces occurs under conditions of both high temperature and high irradiance. Surround reduces fruit surface temperature by increasing the reflection of visible and ultraviolet light (Glenn *et al.,* 2001, Wünsche *et al.,* 2004 and Aly *et al.,* 2010). The effectiveness of Surround in reducing sunburn inmost cultivars and regions may be more strongly ascribed to the reduction in harmful radiation reaching the fruit surface than to the reductions in surface temperature (Gindaba & Wand, 2005), Yuri *et al.* (2000) and Aly *et al.* (2010) reported that high temperature has a stronger influence on sunburn in apples than UV radiation. Schrader *et al.* (2001) distinguish between sunburn necrosis, which occurs at high temperature (>52 °C) and is independent of irradiation and sunburn browning, which occurs at temperatures greater than 46–49 °C in the presence of irradiation.

White coating (Kaolin) significantly reduced fruit pomegranate and leaf surface temperatures relative to the control by averages of 4.9 and 2.5 °C, respectively. Sunburn damage of fruits was reduced from 21.9% in untreated control to 9.4% in the Surround WP-treated fruits (Melgarejo *et al.*, 2004). Also, Applications of kaolin were the best method to prevent sunburn in fruits of the Hicaznar pomegranate cultivar (Yazici & Kaynak 2006 and Weerakkody *et al*., 2010) and Fuji and Honeycrips apple cultivars (Schupp *et al.,* 2002).The kaolin coating significantly reduced fruit surface temperatures mean from 35.4°C in control to 29.3°C in 6 % of kaolin treatment (Safieh *et al.*, 2014).Spraying purshade at 2.0 to 4.0 % effectively depressed sunburned berries % (Faissal *et al.*, 2011).

TABLE 4. Effect of some treatments on Wonderful pomegranate fruit cracking (%), sun burnt fruits (%) and marketable fruits (%) during 2011 & 2012 seasons.

Treatments	Fruit cracking (%)				Sun-burnt fruits (%)				Marketable fruits (%)			
	2011		2012		2011		2012		2011		2012	
Control	5.0	a	6.0	a	30.0	a	33.0	a	65.00	f	61.00	e
Purshade 2%	2.3	c	3.0	b	17.5	d	20.0	d	80.20	c	77.00	c
Purshade 4%	2.0	c	2.0	c	14.9	e	15.0	f	83.10	b	83.00	b
$Ca(OH)_2$ 1%	3.0	b	3.0	b	23.0	b	27.0	b	74.00	e	70.00	d
$Ca(OH)_2$ 2%	2.5	c	2.0	c	21.1	c	22.0	c	76.40	d	76.00	c
Kaolin 2%	2.0	c	2.0	c	14.1	e	16.0	e	83.90	b	82.00	b
Kaolin 4%	1.0	d	2.0	c	12.8	f	13.0	g	86.20	a	85.00	a

Values have the same letter are not significantly different at 5% level using Duncan's Test.

Data presented in Table 5 revealed that, untreated fruits had a significant effect on higher values of lightness (L) and yellowness (b) compared to the other treatments in both seasons of the study. Otherwise, treatment with kaolin at 4% gave the highest value of redness compared with other treatments and control in both seasons.

These results were similar to those reported by (Andrias & Crisosto, 1996, Layne *et al.,* 2002 and Miller & Greene, 2003). Fruit coloration was significantly improved by addition of anti-sunburn, and this may be due to the two different ways that light enhances anthocyanin synthesis and accumulation in apples, by increasing canopy photosynthesis and assimilation supply to the fruit, and this indirectly stimulate anthocyanin synthesis by providing substrate. Another possibility is that the films treatment directly stimulated anthocyanin synthesis (Ju *et al.,* 1999).

Also applications of kaolin increased red color of pomegranate fruit (Yazici and Kaynak, 2006). The color response of apple trees to reflective film was greatest with reflective film treatments (Aly *et al.,* 2010). Covering the orchard by sprays with reflecting films was also effective in increasing light intensity in the tree canopy and improving fruit coloration (Gindaba and Wand, 2007). In the meantime, improved red colour in some cultivars has also attributed to reduced heat stress, which causes anthocyanin degradation (Steyn *et al.,* 2004). The beneficial effect of anti- sunburn compounds in lowering fruit and leaf temperatures and facilitating photosynthesis process could result in encouraging plant pigments formation (Fosket, 1994) and hastening colouring of fruits.

These results are in concordance with those obtained by Kerns and Wright (2002) and Morsy *et al*. (2008). On the other hand, reductions in fruit color are possibly due to an increase in the amount of reflected light, resulting in light-limited carbon fixation and color development (Schupp *et al.,* 2002). Colors of peel changes from brown to black in pomegranate fruits on which sunburn occurred. Furthermore, water content depletion and drying occurs in fruit and this leads to less appeal in marketing and economic losses (Yazici, *et al.,* 2005).

TABLE 5. Effect of some treatments on Wonderful pomegranate lightness (L), redness (a) and yellowness (b) during 2011 & 2012 seasons.

Treatments	Lightness (L)				Redness (a)				Yellowness (b)			
	2011		2012		2011		2012		2011		2012	
Control	45.96	a	37.66	a	32.13	de	32.00	c	26.95	a	23.18	a
Purshade 2%	37.25	c	31.78	d	34.23	cd	31.70	c	15.50	de	19.30	c
Purshade 4%	34.70	d	28.23	f	35.44	c	31.80	c	13.87	e	17.50	d
$Ca(OH)_2$ 1%	33.43	d	36.12	b	24.50	f	25.54	d	10.52	f	16.26	d
$Ca(OH)_2$ 2%	41.09	b	38.00	a	30.83	e	31.00	c	18.33	c	21.15	b
Kaolin 2%	34.00	d	30.04	e	39.21	b	33.15	b	23.22	b	24.00	a
Kaolin 4%	38.87	c	33.75	c	41.84	a	36.40	a	16.17	d	16.00	d

Values have the same letter are not significantly different at 5% level using Duncan's Test.

Fruit juice chemical composition

With regard to fruit juice total soluble solids (T.S.S.), acidity and ratio T.S.S./acidity contents, it can be noticed from recorded data in Table 6, that the difference between all tested treatments including control were statically slight.

In both seasons of the study, data recorded in Table 7 show remarkable and significant improvement in fruit quality in terms of increasing vitamin (C), anthocyanin (%) and total sugars (%) in response to foliar spray with Kaolin at 4%. These results are in harmony with those results obtained by Faissal *et al.* (2011), who stated that, spraying purshade at 2.0 to 4.0 % effectively depressed percentage of total acidity in the juice and improved total soluble solids and total sugars comparing with non- sprayed. On the other hand, reflective films sprayed on apple decreased TSS, total sugars and the increase in acidity (Aly *et al.,* 2010).

TABLE 6. Effect of some treatments on Wonderful pomegranate total soluble solids, acidity (%) and TSS/acidity ratio content during 2011 & 2012 seasons.

Treatments	T.S.S (%)				Acidity (%)				T.S.S/acidity			
	2011		2012		2011		2012		2011		2012	
Control	15.0	a	15.0	b	1.30	b	1.40	c	11.54	a	10.71	b
Purshade 2%	15.0	a	15.0	b	1.30	b	1.40	c	11.54	a	10.71	b
Purshade 4%	15.0	a	16.0	a	1.35	a	1.45	a	11.11	a	11.03	b
$Ca(OH)_2$ 1%	14.0	b	15.0	b	1.32	ab	1.42	b	10.61	a	10.56	b
$Ca(OH)_2$2%	14.0	b	15.0	b	1.31	b	1.42	b	10.69	a	10.56	b
Kaolin 2%	15.0	a	15.0	b	1.33	ab	1.42	b	11.28	a	10.56	b
Kaolin 4%	15.0	a	16.0	a	1.30	b	1.38	d	11.54	a	11.59	a

Values have the same letter are not significantly different at 5% level using Duncan's Test.

TABLE 7. Effect of some treatments on Wonderful pomegranate vitamin (C) mg ascorbic, anthocyanin (%) and total sugars (%) contents during 2011 & 2012 seasons.

Treatments	Vitamin (C) mg ascorbic acid/100 ml juice				Total juice anthocyanin (%)				Total sugars (%)			
	2011		2012		2011		2012		2011		2012	
Control	23.00	d	22.00	c	0.29	e	0.26	d	11.30	e	11.18	b
Purshade 2%	22.50	e	23.20	b	0.30	d	0.27	c	11.80	d	11.20	b
Purshade 4%	24.00	c	24.60	a	0.33	b	0.29	b	12.50	c	12.00	a
$Ca(OH)_2$ 1%	23.00	d	22.40	c	0.29	e	0.26	d	11.00	e	10.90	b
$Ca(OH)_2$2%	23.40	d	22.90	b	0.30	d	0.27	c	11.10	e	11.20	b
Kaolin 2%	25.20	b	24.90	a	0.31	c	0.27	c	12.00	b	11.95	a
Kaolin 4%	26.00	a	25.00	a	0.34	a	0.30	a	12.80	a	12.25	a

Values have the same letter are not significantly different at 5% level using Duncan's Test.

Conclusion

Generally, all treatments were effective in reducing the percentage of Wonderful pomegranate fruit sunburn. In addition, the treatment of kaolin at 4% was more effecting than the other treatments under the same conditions of this study.

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تأثير بعض المعاملات على تقليل لفحة الشمس فى ثمار أشجار الرمان الوندرفول

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أجريت هذه الدراسة خلال موسمى ٢٠١١ – ٢٠١٢ وذلك لدراسة تأثير رش البيورشاد تركيز (٢- ٤ ٪) وهيدروكسيد الكالسيوم تركيز (١ – ٢ ٪) والكاولين تركيز (٢- ٤ ٪) على تقليل لفحة الشمس لثمار أشجار الرمان صنف الوندرفول عمر ٤ سنوات والمنزرعة فى ارض رملية فى طريق مصر اسكندرية الصحراوى. تم رش كل اشجار التجربة مرتين (مرة بعد ٢١ يوم من عقد الثمار وبعد شهر من الرشة الأولي) في كلا الموسمين.

وقد اوضحت النتائج إن المعاملة بالكولين بتركيز ٢٪ أدت إلى زيادة معنوية فى وزن الثمار (جم) ، المحصول (كجم/شجرة) وقشرة الثمار (٪) مقارنة بباقي المعاملات والكنترول. بينما المعاملة بالكولين بتركيز ٤٪ أدت إلى تقليل تشقق الثمار ولفحة الشمس للثمار مما أدى إلى زيادة الثمار التجارية. أيضا المعاملة بالكولين بتركيز ٤٪ أدت إلى زيادة محتويات الثمار الكيميائية (المواد الصلبة الذائبة - المواد الصلبة الذائبة/الحموضة –فتامين ج – صبغة الأنثوسيانين – السكريات الكلية) و احمرار الثمار مقارنة بباقى المعاملات. بينما المعاملة بهيدروكسيد الكالسيوم بتركيز ٢٪ سبب زيادة طول وقطر الثمار. بالإضافة الى أن المعاملة بمادة البيورشاد بتركيز ٤٪ أدت إلى زيادة في نسبة الحب (٪) والحموضة (٪). عموما كل المعاملات كانت فعالة فى تقليل نسبة لفحة الشمس فى ثمار الرمان الوندرفول. بالاضافة الى ان المعاملة بالكولين بتركيز ٤٪ كانت أكثر فعالية مقارنة بباقي المعاملات تحت نفس ظروف الدراسة.